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MINOT'S LEDGE LIGHTHOUSE.

A BRIEF MEMOIR BY THE LATE LIEUT. COL. B. S. ALEXANDER, BREV. BRIG. GEN., U. S. A.

Presented and read April 2d, 1879, by J. G. BARNARD, U. S. Army, Hon. Member of the Society.

PREFATORY REMARKS BY J. G. BARNARD.

On the completion of the work, there remained the sum of $30,000 of the original appropriation unexpended. It was the intention of the Lighthouse Board to devote this unexpended balance to the preparation of a complete history, with plans and pictorial illustrations. But the constructing engineer, the late Gen. B. S. Alexander, relieved from the work only a few weeks before the breaking out of the war, was called upon for services in arduous and absorbing labors during the whole period of its duration,

Hence he was prevented, while the history of the work was yet fresh in his mind, from undertaking it. Soon after the war he was ordered to the Pacific Coast, where he remained in active discharge of his duties until his death. Unaddicted to writing or sedentary work of any kind, and separated from the documentary collections of the lighthouse establishment, he was never properly situated for the execution of a work to which, besides, he was little inclined.

The following brief memoir was prepared four years ago for, and at the earnest solicitation of, the writer. It is believed to be the only connected memoir, by its author, on the subject.

GENERAL ALEXANDER'S MEMOIR.

The iron lighthouse was carried away in the spring of 1851.*

The present Lighthouse Board was organized in 1852. It was immediately determined by that board to replace the former structure, if possible, by a stone tower.

A careful survey of the rock was made by Major Ogden, of the Corps of Engineers, acting under orders of the Board.

This survey was what may be called a topographical survey, with horizontal curves only three inches apart. In other words, the survey showed a plan of the rock at low water, with the curves where horizontal planes passed three inches from each other vertically, both above and below that level, would intersect the rock, all these curves being projected on the plan.

The survey showed that the top of the highest point of the rock was 3′ 6″ above the plane of low water, It also showed that it would not be possible to obtain a tower of a greater diameter than 22′ without going outside the line of low water. This diameter was not considered sufficient either for stability or accommodation. But it was also shown that by going outside of and below the line of low water, in five places, it might be possible to obtain a tower of 30′ diameter.

The survey was placed in the hands of Gen. Totten, then Chief Engineer of the United States Army and member of the Lighthouse Board, who took upon himself the duty of planning a masonry tower for this

* Reference is here made to the iron skeleton tower designed and erected (1845–48) by Capt. W. H. Swift, U. S. Topographical Engineers, destroyed by the great storm of April 14–17, 1851. An account of this structure, as also of the circumstances of its destruction, will be found in Johnson's Cyclopædia, article, *Lighthouse Construction* (J. G. B.).

difficult position. With the exception of the lower stones of the foundation, which had to be studied out on the rock itself, and some details of construction, the tower was built, throughout, according to the plan of Gen. Totten.*

In April, 1855, Lieut. Alexander, of the Corps of Engineers, U. S. A., was assigned to the duty of constructing the lighthouse. He furnishes the following notes descriptive of the method of overcoming some of the difficulties in the construction of the work.

I first visited the vicinity of Minot's Ledge on the 1st of May, 1855. The weather was fine, and I hoped to land on the rock the next day. But on the following morning, I found an "old swell" running which prevented any boat from approaching the rock. This "old sea" or "old swell" continued with variable weather until Saturday, the 12th of May, when I succeeded in landing on the ledge for the first time. The stumps of the broken iron piles of the old lighthouse first attracted my attention. They had a melancholy appearance; they told of disaster, and the determination to remove them was involuntary. The wreck of the old lighthouse was visible under water, as we stood on the rock, and I determined to remove it also. (For the appearance of these remains, see the Fig. 3, article already cited, Johnson's Cyclopœdia.—J. G. B.)

It was difficult to stand on the rock. It was covered with mussels and seaweed, but otherwise was much as I expected to find it. I examined it carefully, and measured it at dead low water in hopes to be able to report that we might get a few inches more than thirty feet diameter for the foundation; but I was disappointed in this hope. After waiting about an hour, the rising tide drove us off, but I visited the rock again on the following day, and with the same feelings as before.

How was it possible to cut down this rock into any shape suitable to receive the foundation stones of the tower? Could it be done?

We could not land, even in the summer season, at times for weeks together; and when we could effect a landing, a part of the ledge was at all times under water, and the remainder only bare for one or two hours at low water of spring tides. The space was contracted, and the sea broke with such violence during easterly weather that no coffer dam was possible. How were we to begin? What should be the process? Where

* The "Annual of the National Academy of Sciences," 1866, gives a full account of the connection of the late Gen. Totten with this work. J. G. B.

were the workmen to live, and what were they to do while waiting for an opportunity to land on the ledge ?

The ten or twelve days I had spent on shore, or on the buoy tender, while waiting to effect a landing, enabled me to reflect seriously on these subjects, and, in fact, to solve these problems.

I could foresee that cutting the rock into shape to receive the foundation stones would prove to be a very tedious, troublesome and expensive operation, and one requiring incessant vigilance. I knew, if we hoped to establish this foundation in any reasonable time, that when we were enabled to land we must do so with a large party of skilled workmen, with all the necessary tools and implements.

To have engaged such a party of workmen and placed them on board vessels near the rock, or on the shore in sight of it, with instructions to take advantage of every opportunity to work on the foundation pit, would have been an easy operation, but it would not have been good engineering.

The men would have been idle nine-tenths of the time. They could not have been kept properly disciplined ; when wanted they would not have been at their posts, and even if they had been they could not have worked like men who are used to daily labor. Their hands would soon have become soft, and they would shortly have become physically disqualified for such hard labor and exposure as I had before them.

I determined, therefore, to combine the operation of cutting down the rock for the foundation with the cutting of the stone for the tower, and have them both done by the same party of workmen, to whom I could give constant employment and full wages. To accomplish this it was necessary to have a *shore establishment* ; that is to say, an establishment on the shore, as near the lighthouse as posssible, with wharf accommodations, storerooms, workshops, and a stone-yard where the stone could be cut and fitted together preparatory to being removed to the tower.

By providing the necessary vessels and boats, a gang of stonecutters could then work on the ledge when sea, weather and tide would permit, and when they would not, there would be full employment for these men on shore, cutting the stone for the tower.

I determined also to erect a permanent scaffold on the ledge, not a beacon-house, but a structure of iron to which the workmen could be

secured, to protect them from being washed fron the rock, and afford means of temporary security in case of accident to the boats or vessels. This scaffold I also conceived would answer the purpose of a derrick for laying the lower courses of masonry in the tower, and the lighthouse being built around the piles of this scaffold, they would be so many huge bolts to secure it to the foundation of the rock.

All these ideas were embodied in my first report to the Lighthouse Board, dated May 31st, 1855. They were approved, and I immediately set about carrying them into execution.

On the twentieth of June I employed a few men to loosen the wedges around the stumps of the old iron piles and remove the mussels from the top of the ledge. This work was accomplished in a few days.

Having supplied a few tools, and selected Mr. Charles Pratt, of Cohasset, as Superintendent of the work, on account of his great experience in masonry constructions, our small party landed on the rock at daylight on Sunday morning, the 1st day of July, 1855.

The morning was beautiful, clear and calm; just as the sun was rising above the horizon I took a hammer and chisel, called the party together, and, after a few remarks to them, commenced cutting a bench-level on the highest point of the rock. This bench-level was the point from which all levels were to be taken while cutting down the foundation.

As the whole of the top of the rock down to a plane 1 foot 9 inches below this bench-level, was to be removed, we began on this day and continued for several days to mark points of intersection of this plane with the surface of the rock, cutting thereby level space around the rock upon which the workmen could stand and upon which tools could be placed in comparative safety.

Knowing that the upper portion of the rock, inside of this level space, could easily be cut away long before the foundation on the lower levels could be got ready, no more of it was removed during this season than was absolutely necessary.

Points of the lower levels, defining the portion of the rock that was to be cut away, were also marked whenever the tide would permit. This could be done as well by a small party of men as by a large one; and as it was evident we could not do much work on the rock during the first season without disregarding all economical considerations, I only

employed a small force and confined our labors, in a great measure, to laying out the work for a larger party for the the next year, and in this way we all acquired valuable experience.

In the year 1855 we worked on the rock 130 hours.

1856.

We first landed on the rock this season on the 1st of April.

One of the greatest difficulties in preparing the foundation was in cutting the vertical surfaces of the rock so as to receive the vertical joints of the foundation stones. The level surfaces could be more easily prepared, because the rock could be plugged off and the surface brought to a plane, even when there was a depth of two or three feet of water over the space to be cut,

There were to be two partial courses of stone in the foundation before the first full course of masonry. The form of every stone in this foundation had been carefully worked out by Gen. Totten; but owing to blind seams in the rock, and to an accident, to be mentioned hereafter, the number and sizes of the stones had to be altered. As finally finished, there are seven stones in the lowest or partial course, all having the levels of their bottom beds below low water, the levels of these bottom beds varying in depth from seven inches to two feet two inches below low water level, the last depth being the level of the bottom bed of the lowest stone in the structure. There are twenty-nine stones in the second partial course; of these, twelve stones have their beds below low water, varying in depth from four inches to one foot two inches below low water.

The following is an outline of the manner of cutting the vertical surfaces around the outside of the tower, and along the inside lines to which the rock was shaped to receive the stones of the lowest courses fitting into it.

The men were provided with 1¼ inch drills, from 2 to 4 feet long, and having marked the ends of a line upon which a vertical surface was to be cut, they would start, at low water, as many holes as possible, about one inch apart, carrying these holes down, at first, to the depth of only one or two inches. During a good tide, three men, one to hold the drill, and two to strike, would start from 20 to 30 holes.

When a line was thus marked these holes became guides, into which

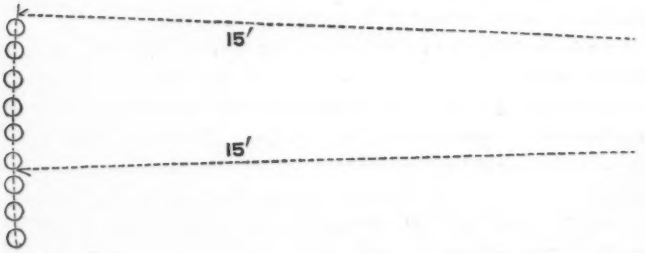
longer drills of the same size could be inserted without danger of making mistakes, even when there was two or three feet of water on the rock. These holes were then drilled down to the exact depth required.

The spaces between these holes were then "set out," that is to say, the stone between the holes was crushed out by a "set," like that used by stone cutters in "setting out" Lewis holes.

This set was nothing more than a piece of octagonal steel, like an ordinary drill, but made so as to be about seven-eighths of an inch by one and one-half inches on the bottom, so as to cover the space between two adjacent holes. Having placed this tool in its proper place, it being too large to enter the holes made by the drills, it was driven to the bottom of the holes with the ordinary striking hammer.

These holes and this setting-out process, having been carried to the required depth all the way around any particular portion of the ledge to be removed, disconnected that portion from the rock to which it had been joined. It was then easily removed, without danger of injuring the adjacent parts.

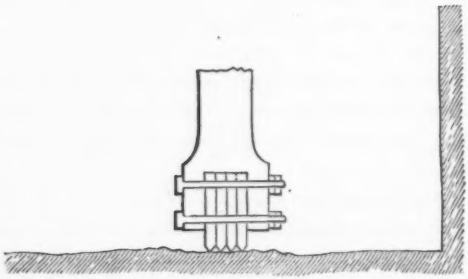
This drilling and setting-out process was carried along all the interior lines of vertical cutting, as well as around the outside or circumference of the foundation pit; the centre of the holes, in the latter case, being placed, as nearly as possible, on the circumference of the base of the tower, or fifteen feet from its centre. Thus:



So that when the circle was set out and trimmed up, the foundation pit was about one-half an inch larger, all around, than the first complete course of stone in the tower; or, in other words, the radius of the foundation pit was fifteen feet and one-half an inch.

The vertical surfaces were "trimmed up," or brought nearly to a plane surface, by chisels and hammers, after the rock, on the side where it was required to be removed, had been knocked out of the way; and the different levels of the foundations, where they were exposed at low water, were hammered in the same way.

But where the stone was *always* covered at low water the stone was first drilled or knocked or plugged off until it was brought down *nearly* to the required level, and then a tool, of which the following is a representation, was used to take the place of the ordinary hammer or chisel:



With tools like this we were enabled to hammer down the surfaces of the lower levels of the foundation pit, even when there were two or three feet of water over the spaces to be hammered.

It has been stated that a permanent coffer dam around this work was out of the question, but I found temporary coffer dams around small portions of the rock of great use, both in finishing up the foundation pit and in laying the lower stones of the structure. These coffer dams were made with sandbags like those we use in building a sandbag battery. The duck was heavy, and, therefore, practically water-tight; the bags being filled about half full of sand. They were, therefore, easily handled. Two or three hundred of these bags built up, at low water, around a small portion of the foundation pit which it was desired to finish, or where we wanted to lay a stone in mortar, would keep out the water for fully half an hour, if the sea was very smooth. The water in the little pit, where we wanted to work, was then bailed out, and by means of large sponges it was kept nearly dry.

These little dams only required a few moments in construction, and, as they were easily removed, they were inexpensive. They answered an admirable purpose in enabling us to see that the work was correctly done; see that the foundation was properly completed; see that the wooden patterns for the lower stones were correct; and then have the satisfaction of seeing the lower stones laid in a bed of mortar, properly spread on its foundation.

Nearly all the stones were thus laid; a few required another device.

Iron Scaffold.

During the month of June, 1856, an iron scaffold was erected on the rock.

It consisted of nine wrought iron shafts inserted into the holes of the iron lighthouse and rising to a height of twenty feet above low water; the whole bound together at the top by a strong wrought iron frame.

The posts were ten inches in diameter at the rock, and seven inches in diameter at the level of the frame.

This scaffold gave us some command of the rock, and it gave great confidence to the new hands. By stretching lines between the posts across the rock in different directions, about two or three feet above it, every workman had something within his reach to lay hold of when a wave would break over the rock, thus doing away with the constant apprehension of danger.

In 1856 we worked on the rock 157 hours.

1857.

On the 19th of January of this year, the bark "New Empire," loaded with cotton, was thrown against our scaffold during a violent northeast gale, and swept it from the rock, breaking off the iron posts very much as those of the iron lighthouse had broken when it was carried away, and shattering the top of the rock, in some places, so that a portion of our labor during the preceding year had to be done over again.

This was a very unfavorable season for work; the whole working time on the ledge being only 130 hours. Nevertheless, the foundation-pit was nearly completed, and four stones of the foundation were laid.

1858

was a much more favorable season. The foundation pit was finished this year, and the masonry of the tower was carried up to the 6th course (inclusive).

The mortar used throughout the structure was the best quality of pure Portland cement. No lime or sand was used.

The lowest stone was laid July 11, 1858. This stone, and some six others, had to be laid in the water.

The method adopted for securing a bed of mortar under these stones, and also on their vertical joints, was as follows: A large piece of thin muslin was spread on a platform on the ledge. A layer of mortar was then spread over it of the required thickness. The stone was then laid on this bed of mortar. The vertical joints of the stone were then plastered with mortar. The cloth was folded up and laid smooth along these vertical joints, cutting away its superfluous parts. After remaining five or ten minutes the mortar would begin to set so that it and the attached cloth would adhere to the stone. The stone was then laid in this envelope, which protected the mortar from the dissolving action of the water while it was being lowered into position. I had previously made some experiments at our wharf by cementing stones together in this way under water, and they satisfied me that the mortar would ooze through the threads of the cloth so as to form a good bond to the stone below.

All the lower courses of stone in the tower were laid from an iron mast, which was set up in the centre hole of the former lighthouse. The machinery and rigging, which completed the derrick, had to be put on and taken off this mast every day that we landed for the purpose of laying masonry. It was of simple construction, and arranged so as to float in the water, so that all we had to do in "stripping the derrick," after our tide's work was over, was to cast the machinery loose from the mast and throw it, with the attached rigging, overboard. It could then be towed to the tender.

We worked on the rock this year 208 hours.

1859.

The masonry of the tower was carried up this year to the top of the 32d course, being 62 feet above low water.

Working time on the tower this year 377 hours.

1860.

The lighthouse was completed this year. The last stone was laid on the 29th day of June, which was just five years, lacking one day, from the time the workmen landed on the ledge.

No life was lost in building this lighthouse, nor was any person seriously injured.

The following were the principal regulations for the safety of the workmen while cutting down the ledge and laying the masonry of the foundation :

1st. No person should be employed on the work who could not swim, or who could not pull an oar and manage a small boat.

2d. No landing on the rock should ever be attempted from one boat. There must always be, at least, two boats.

3d. While the workmen were on the ledge, a small boat with at least three men in it should be stationed immediately alongside the rock, on its lee side, to pick up the men who were occasionally washed from the rock.

Beginning at the third, or first full, course of stone, all the stones in the lighthouse were fitted together at our shore establishment; each stone occupying the exact position it was afterwards to take in the tower.

We would build up eight courses of stone on a platform, then take down top or eighth course and fit it together again on another platform, which then became the foundation upon which the 9th, 10th, 11th, and subsequent courses were fitted.

The stones on the first platform being marked and laid away in the stone yard in the order in which they would be wanted at the tower.

The foundation stones were secured to the ledge by galvanized wrought-iron bolts, inserted through these stones and into the ledge to the depth of one foot.

The stones of the solid portion of the lighthouse were secured to the courses below by similar bolts entering seven inches into the lower course.

After the destruction of the scaffold which had been erected on the ledge, a new one was prepared similar to the first, but it was never erected as a scaffold. The eight outer posts, however, were inserted in the eight outer holes of the former lighthouse, after the masonry of the tower had been carried up to the 10th course, the spaces around these posts being filled with a grout of Portland cement. They are supposed

to give additional strength to the tower, holding it more securely to its rock foundation.

The light was exhibited for the first time at sunset, November 15, 1860.

The cost of the lighthouse, and of the keeper's houses on shore, was $300,000.